NATIONAL HARBOR BUILDING M

OXON HILL, MARYLAND

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Structural Option
Thesis Proposal
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EXECUTIVE SUMMARY

National Harbor Building M is being constructed as part of a large scale development on the banks of the Potomac River which will be known as National Harbor. It is a rectangular building in shape with dimensions of 243'-8" x 60'-5 ½" for approximately 14,800 square feet per floor. This five story building resists lateral forces through four masonry shear walls in the longitudinal direction, and a combination of six moment frames and two braced frames in the transverse direction.

After carefully and thoroughly analyzing this Building M in three technical reports, it was determined the building efficiently serves its purpose as a tenant fill out office/ retail building. The original design does an adequate job of providing open spaces through the relatively long spans of the column layout. The goal for the further investigation of Building M is to attempt to match the effectiveness of the existing design with a different structural system. A post-tension concrete floor system in a concrete building was selected because of its ability to span longer distances while maintaining a shallow structural depth.

This proposal outlines the methods which will be used, the tasks which will need to be completed, and a preliminary schedule for completion of the redesign of National Harbor Building M. In addition to the conversion to a post-tension floor system, the building's columns and lateral system will be redesigned in concrete for consistency. A mechanical investigation will be performed in an attempt to take advantage of the increase in useable space provided by the post-tension slab. Finally, a construction investigation will take place to see if the proposed system can be accomplished at this site in a shorter time period or at a lower cost than the existing system.

INTRODUCTION

National Harbor Building M is a tenant fill out office building in the new National Harbor Development located on the Potomac River in Oxon Hill, Maryland. The building has a structural steel frame with a glass and precast concrete façade. It is an approximately 81,00 SF building containing five stories with a typical floor to floor height of 13’-4” . The building’s first floor entrance is centrally located on the longitudinal face of the building which faces the waterfront. The entrance leads into the building’s lobby which provides access to the elevators. Additional access can be gained through the stairwells located in the adjacent parking garage. The first floor of Building M is to contain retail and office occupancy, while the upper four stories are designed strictly as office space.

EXISTING SYSTEMS OVERVIEW

Floor System:

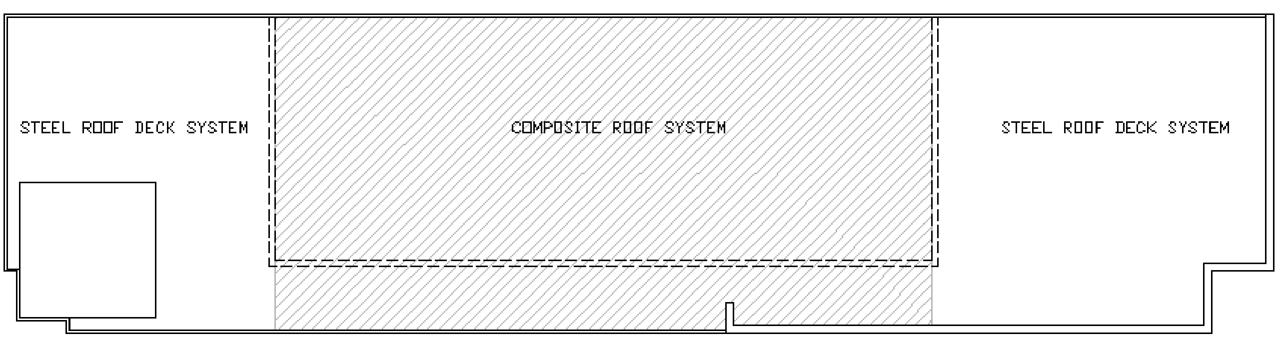
The typical floor is a 6-1/4" thick composite concrete system. It is comprised of a 3-1/4" light weight concrete slab with 3000 psi compressive strength and a 3"-20 gauge A992 (50 ksi) composite steel deck. The slab is reinforced with 6x6-10/10 draped welded wire mesh (WWM), and gains its composite properties from ¾" diameter 5-1/4" long steel studs. This composite floor system is supported by A992 wide-flange beams which are typically spaced at 10' on center, span 30'-5-1/2" in a normal bay, and have a 1" camber. These beams range in size from W14-22 to W16x26, and are in turn supported by a grid of wide flange girders. The girders typically are spaced at 30'-5-1/2" with a 30'-0" span ranging from W18x50 to W24x84 with a 1" camber.

Column System:

The columns are ASTM 572, grade 50 or A992 steel wide flanges, and are laid out in fairly square bays (30'x30'-5-1/2" typ.) forming a mostly rectangular grid of 9 bays by 2 bays. They are the main gravity resisting members of the structure, as well as a portion of the lateral resisting system. These major gravity resisting columns range from W12x65 to W14x109 at the bottom level, and are spliced 4' above the third floor level. There are lateral force resisting columns in both moment and braced frames which range from W14x99 to W14x211 at the bottom level, however, they tend to be on the order of W14x150s. These columns are also spliced at a distance 4' above the third floor level.

Roof System:

The roof of this structure is constructed in two different systems: typical flat roof steel deck and a composite slab roof construction. The main roof is 3" 18 gauge wide rib, type N galvanized steel roof deck which is uniformly sloped. The other roof system is a 4-1/2" normal weight composite concrete slab with 3000 psi compressive strength, and reinforced by 6x6-10/10 draped WWM supported by 3" 18 gauge composite steel deck. The composite action in this slab, as in the standard floor slabs, comes from ¾" diameter 5-1/4" long equally spaced studs.



ROOF CONSTRUCTION PLAN

Foundation System:

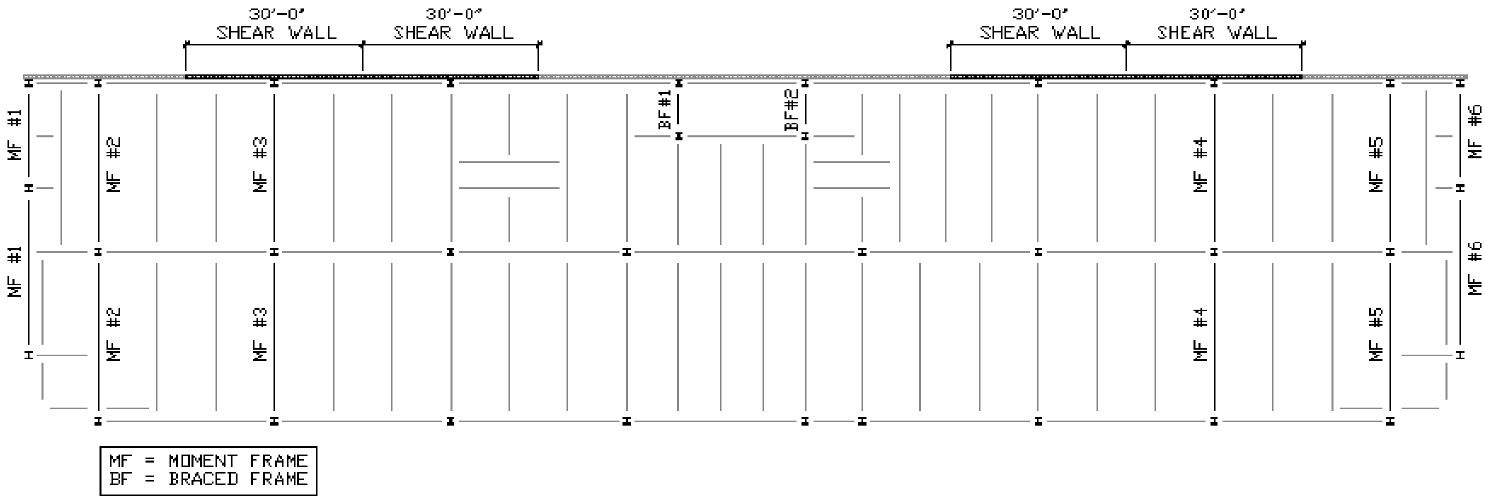
The ground floor is constructed of a 4” thick slab on grade with a compressive strength of 3000 psi, and reinforced with 6x6-10/10 WWM. The columns are supported by concrete footings, compressive strength of 4000 psi, which are in turn supported by driven 14” square precast prestressed concrete piles. The piles, which have an axial capacity of 110 tons, uplift capacity of 55 tons, and a lateral capacity of 7.5 tons, are typically arranged in three pile groups under the exterior columns. These pile groups and footing combinations are connected by reinforced concrete gradebeams running around the exterior of the foundation system. The columns, which form the braced frames around the elevator core, are additionally supported by a reinforced concrete pedestal and a 43 pile mat-pile group footing. The mat supporting these piles, 18 of which are uplift piles, is approximately 21’x 48’ x 64” deep.

Masonry Wall System:

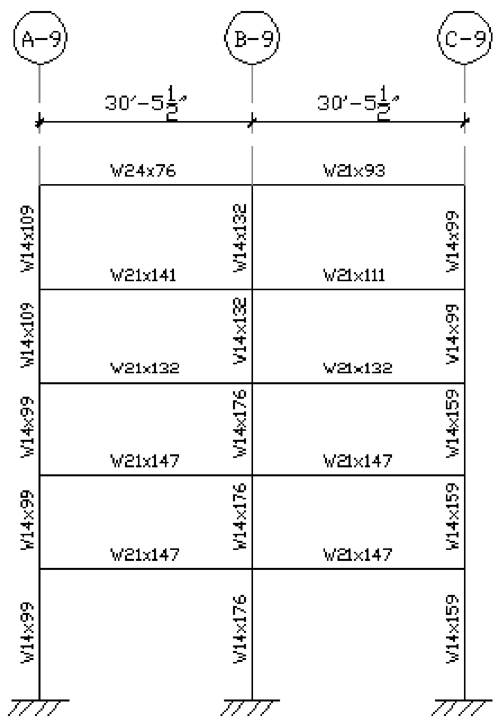
The eastern wall of the structure is backed up by a full height 8” CMU masonry wall running the length of the building, 243’-8”. The wall acts as a barrier between the office building and an adjacent parking garage being concurrently constructed. It separates the two with a 4” expansion joint on the parking garage side, and ties into the structure at every floor level with a standard bent plate connection every 32” on center. The wall is reinforced with one or two #6 bars at a spacing of 8”-24” on center depending on the location. It is additionally reinforced with bond beams for impact loads from the parking garage of 6000lbs at a height of 1’-6” above the floor levels. In addition to being a barrier section of the CMU wall, it also acts as (4) 30’-0” masonry shear walls to aid in the lateral force resisting system.

Lateral System:

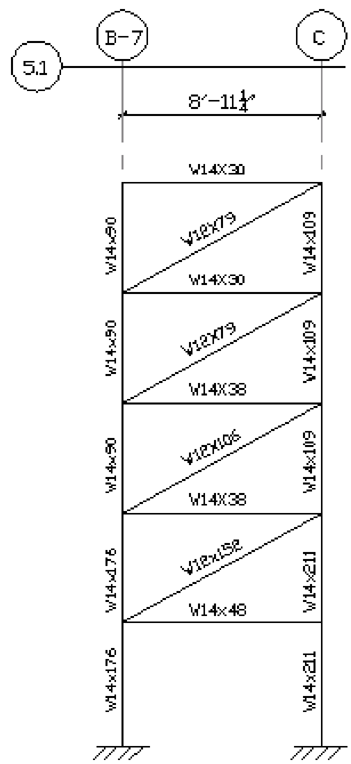
This building’s lateral force resisting system is a combination of multiple system types which act together to laterally support the building. It contains (6) 2-bay moment frames which run in the east-west or transverse direction of the building. Of the (6) moment frames, only two (MF #3 and MF #4) occur at the first two levels, while the other (4) frames extend to the top of the structure. They are arranged symmetrically with (2) moment frames at each end of the grid, and another at one full bay in from each end. The structure also has (2) 1-bay braced frames running in the transverse direction centrally located flanking the elevator core. These braced frames are comprised of wide flange columns, beams, and diagonal members, with the diagonal resisting members ranging from W12x79 – W12x190. The final components of the system are (4) 30’-0” reinforced masonry shear walls located in the 8” CMU wall running in the north-south or long direction of the building. The connection between the masonry walls, including the shear walls, is designed to allow the steel frames and shear walls to act independently when resisting lateral forces. Where the columns of the steel frames meet the adjacent wall, the masonry is notched back to 6” from 8”. The typical connection made between the concrete slab and masonry shear wall consists of a 3/8” bent plate that is vertically slotted at the shear wall face. The vertical slots allow for slabs, columns, and beams working in the transverse direction to deflect without adding out of plane stiffness to the frames. The connection, not slotted in the horizontal direction, is still able to provide lateral bracing for the masonry wall. Also, it engages the shear walls longitudinally as they resist the majority of lateral forces in that direction. Shown below is a typical framing plan calling out the lateral members, elevations of typical lateral members, and a typical connection between the frames and the masonry wall.



TYPICAL FRAMING PLAN

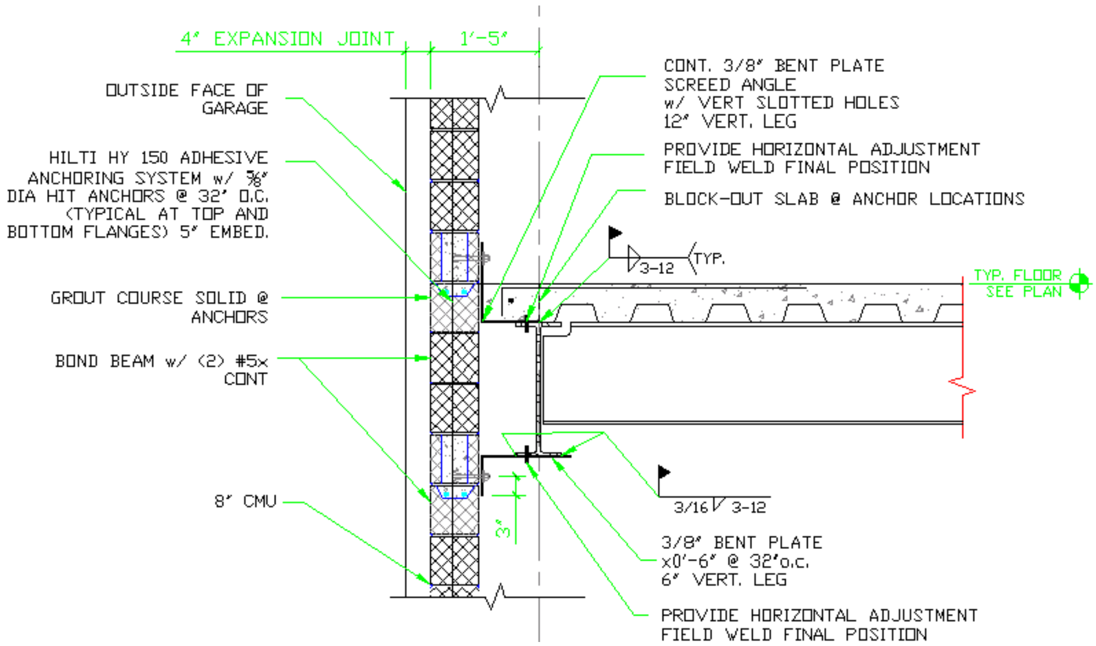


TYPICAL MOMENT FRAME



TYPICAL BRACED FRAME

*Note:
Frames not drawn to scale, all story levels are same height.



<u>Typical Slab to Shear Wall Connection</u>

THESIS STATEMENT

Through the research compiled in previously composed technical reports, it is apparent Nation Harbor Building M has no significant problems which need addressed. The building successfully provides open interior spaces with large spans suitable for office occupancy. Building systems such as mechanical and electrical are designed with flexibility in mind to allow future tenants to adapt spaces to their specific needs. Changes or modifications to the building's design or system layouts will attempt to improve upon, or at the very least, maintain the current level of building efficiency.

THESIS PROPOSAL

A post-tensioned two-way flat slab will be designed to replace the existing steel structure and composite deck system. The post-tensioned system will be able to achieve similar results regarding the long spans and open spaces. Additionally, the proposed system will have a smaller overall structural depth, allowing for greater flexibility in the design of the building's systems. Along with the conversion to a concrete floor system, the building's columns, as well as its lateral systems, will be addressed. In being consistent with the concrete floor system, concrete columns will be designed to carry the loading of the new floor system, and will replace the current wide flange columns. The lateral system will be changed from a combination of steel moment frames, braced frames, and masonry shear walls to a combination of concrete moment frames and shear walls. The new lateral system will attempt to not disturb the openness of the current design, while trying to address the large torsional loads the layout of the previous system generated.

Breadth Topics:

- The complete redesign of Building M from a steel based structure to a concrete structure will drastically affect the project delivery. A detailed cost and schedule evaluation will determine if the proposed system can be delivered faster and/or cheaper. Also, a site utilization plan will be constructed to determine if the site can provide access to necessary equipment such as concrete trucks. Should the concrete redesign prove to be cheaper and/or faster to construct while maintaining the goals of the original project, it will be considered a viable alternative solution.
- A mechanical investigation will be performed to try and take advantage of the additional space provided from the switch to post-tensioned flooring. The investigation will look for ways to further increase the flexibility of the space and its ease of adjustment for future tenants.

METHODS

Structural Depth:

The redesign of National Harbor Building M will use all parameters from the original design which apply, and use ASCE 7-05, ACI 2005, and PCI as the basis for the new design. The post-tension floor system will be designed based off of the existing column grid to maintain the building's layout. A RAM Concept model will be created for design purposes, and will be backed up by hand calculations. Review of design examples and post-tensioning basics presented in previous courses, code references, and post-tensioning application lectures will provide the basis of research to complete these tasks. The concrete columns will be designed using PCA column and CRSI Handbooks. The SAP model will be created to aid in the design of the lateral system. Wind and seismic loads determined in previous technical reports will be modified as needed and entered into the model. The lateral load distributions obtained from the SAP model will be used to design the shear walls and other lateral components by hand. Upon completion of the building redesign the foundation system will be inspected based upon given pile capacities to ensure it is still adequate to support the structure.

Breadths:

- The Construction breadth will concentrate on cost, schedule, and site feasibility. R.S. Means 2005 will be used to perform project take-offs and determine an approximate overall price for the redesign. Schedules and site utilization studies will be created with the aid of research and input from Construction Management students and faculty.
- The Mechanical breadth will concentrate on how the system will change with the conversion to a concrete based building. A thorough review of the existing mechanical plans will be performed to become more acquainted with the system's original layout. Discussion with mechanical students and faculty will be used to analyze the effects the change will impose on the system.

PROJECT TASKS

1. **Design of Post-Tensioned Floor System:**
    - Create RAM Concept model for starting point of design
    - Determine required slab thickness
    - Design post-tensioned tendon layout
    - Examine special conditions of slab (cantilevered corners, slab openings)
    - Evaluate final shear and moment capacities and deflections

2. **Design of Concrete Columns:**
    - Compile live loads from ASCE 7-05 and dead loads from new floor system
    - Design concrete columns using PCA Column and CRSI Handbook

3. **Lateral System Design:**
    - Revise lateral forces from previous report to comply with redesign
    - Create SAP model to determine lateral load distribution
    - Design shear walls based on load distribution determined in SAP
    - Analyze the concrete moment frames
    - Analyze drift and displacement of the building in critical directions

4. **Additional Design Tasks:**
    - Check capacity of foundation prestressed precast piles
    - Modify pile layout where required
    - Design new foundation under new shear wall location

5. **Construction breadth:**
    - Compile and compare cost take offs on both structural systems using R.S. Means
    - Compile and compare schedules for both structural systems
    - Create site utilization map analysis of concrete structure

6. **Mechanical Breadth:**
    - Establish location of mechanical system in concrete structure
    - Coordinate new access to each floor through designated slab openings
    - Resize/ relocate mechanical equipment based on new space availability

7. **Final Project:**
    - Write final report
    - Create final presentation

PROPOSED SCHEDULE

TASK	WEEK 1 1/13 - 1/19	WEEK 2 1/20 - 1/26	WEEK 3 1/27 - 2/2	WEEK 4 2/3 - 2/9	WEEK 5 2/10 - 2/16	WEEK 6 2/17- 2/23	WEEK 7 2/24 - 3/1
Research Post-Tensioning	X						
Create RAM Concept Model	X	X					
Design PT Floor System		X	X				
Design Concrete Columns				X			
Create SAP Model					X		
Revise Lateral Loads					X	X	
Design Lateral Members						X	X
Additional Design Tasks							X
Cost/Schedule/Site Investigation							
Mechanical Investigation							
Create Report							
Create Presentation							

TASK	WEEK 8 3/2-3/8	WEEK 9 3/9-3/15	WEEK 10 3/16-3/22	WEEK 11 3/23-3/29	WEEK 12 3/3-4/5	WEEK 13 4/6-4/12
Research Post-Tensioning						
Create RAM Concept Model						
Design PT Floor System						
Design Concrete Columns						
Create SAP Model						
Revise Lateral Loads						
Design Lateral Members						
Additional Design Tasks	X					
Cost/Schedule/Site Investigation			X			
Mechanical Investigation				X		
Create Report					X	X
Create Presentation						X

CONCLUSION

The main goal of the proposed post-tension floor system is to attempt to maintain the large spans and open spaces provided by the original system which are necessary elements of a tenant fill out office building. In staying consistent with the concrete redesign, the building columns and lateral system will be redesigned accordingly. A mechanical investigation will be done in an attempt to take advantage of the proposed system's shallower structural depth. Additionally, a site, schedule and cost investigation will be done to determine if the proposed system has construction benefits the original system cannot offer. Should the post-tensioned concrete system allow for the same spans and open spaces while presenting benefits in the noted areas, it shall be considered a viable alternative for National Harbor Building M.